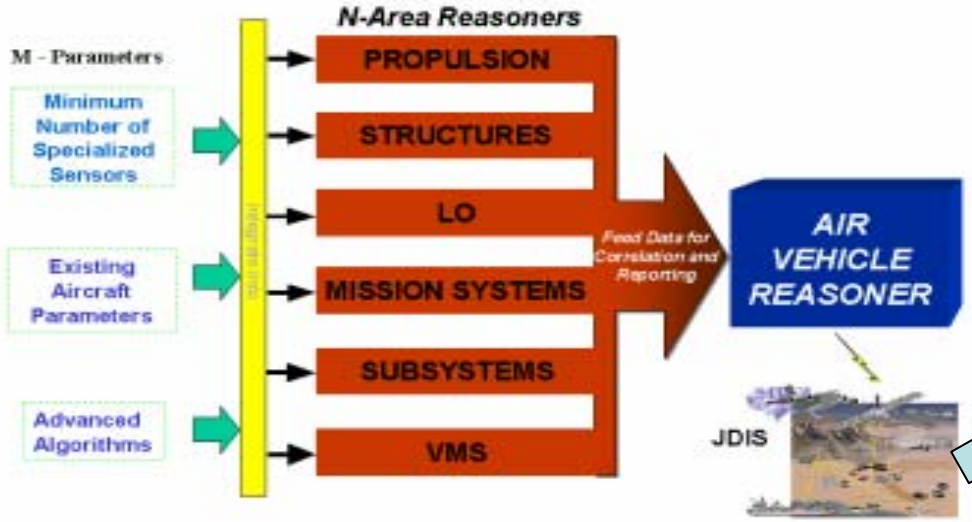
Automated Vehicle Health Management

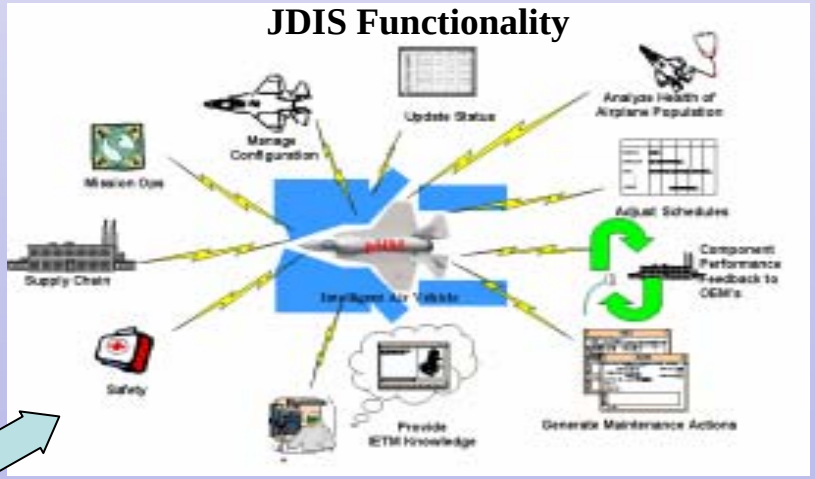
(AKA prognostics and Health Management (pHM): An automated complex system health assessment concept that employs a hierarchal artificial intelligence architecture for determining the current state of individual system health and predicting the future state of health of individual systems and the population of systems given a planned operating environment. This health management concept features:

- **Automated fault detection**
- **Automated fault isolation**
- **Automated fault prediction**
- **Automated or operator assisted fault accommodation (contingency management)**
- **Automated fault and prognostic reporting**
- **Accurate control of Type A and Type B errors**
- **Elimination of CND and RTOK maintenance actions**

Architecture



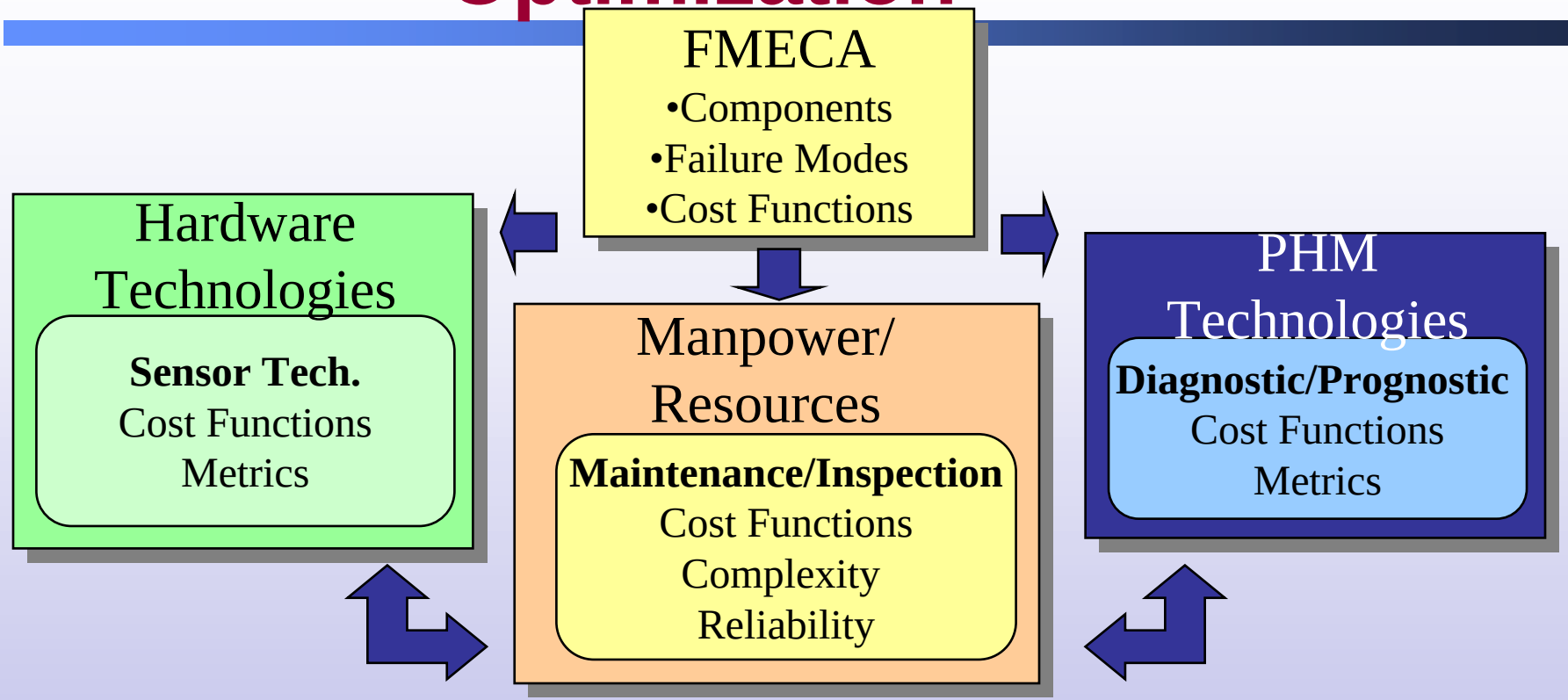
JDIS Functionality



System Integration of Prognostics

- Automated System Health Management
  - Get the most out of the individual weapon system through knowledge of direction and magnitude of its health vectors
  - Enable opportunistic Maintenance
  - Maximize efficiency of supply system
- Focus of the current project: Monitoring of individual component material variability and material response to operational use as a means of predicting future mission capability

Health Management Design Optimization



Health Management Fitness Function

MIN $\sum_{i=1}^{\#\_components}$ Sensor FF (Reliability, Complexity, etc.)$_{Comp(I)}$ + Diagnostic/Prognostic FF (metrics, etc.) $_{Comp(I)}$ + Maintenance/Inspection (effectiveness, man-hours, etc)$_{Comp(I)}$

MAX $\sum_{i=1}^{\#\_components}$ Availability (Reliability, Maintainability, Manning, etc.)

Structure of PHM Design Cost Function

For each Failure Mode – FM(i)

Step 1) Probability of Failure * Severity *Consequential Cost of FM(i) +(Downstream Failure Mode Consequential Costs) * Probability of Propagation

Step 2) *HM risk reduction attributed to FM(i)

Step 3) + Cost associated with False Alarms on FM(i)

Step 4) + Total Cost of all HM technology

Step 1 and 2 =

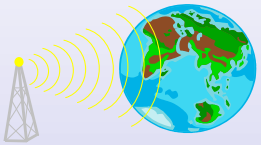
$$\sum_{FM_i}^{FM_n}\left\{\left[\prod_{D_{FMi}} DC\cdot\frac{\sum_{S_D} OQ(1-SPf)}{NsensorsD}\cdot\prod_{P_{FMi}} PA\cdot\frac{\sum_{S_P} OQ(1-SPf)}{NsensorP}\right]\cdot\left[\left(Pf\cdot S(CC+M)\cdot Pp\right)+\sum_{FM_{i+1}}^{FM_n} Rolled\_Up\right]\right\}$$

Where "Rolled Up" =

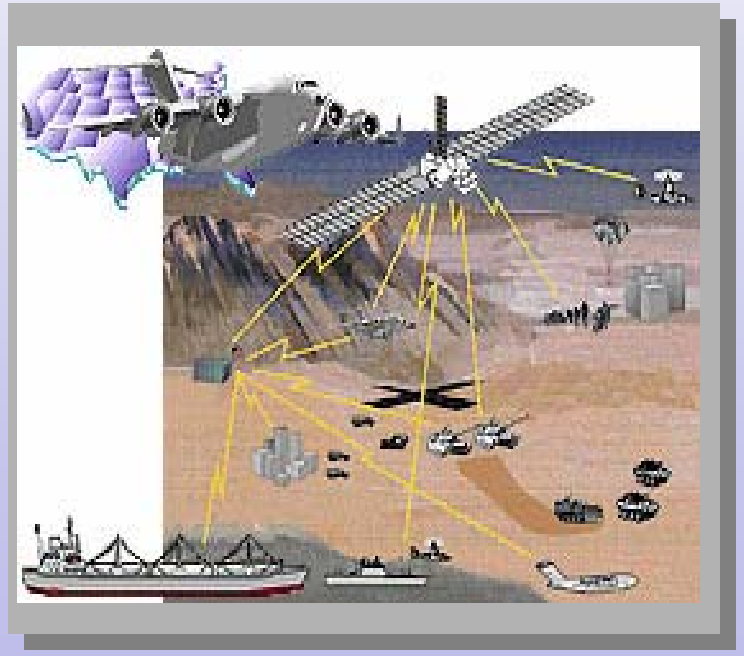
$$Pf\cdot S(CC+M)\cdot Pp\cdot\left(\prod_{D_{FMi}}\left(1-\frac{\sum_{S_{FMi}} OQ}{NsensorsD}\right)\cdot DC\cdot\prod_{P_{FMi}}\left(1-\frac{\sum_{S_{FMi}} OQ}{NsensorsP}\right)\cdot PA\right)$$

What Prognostics can do for the Warfighter

- **Accommodate Exigencies of Warfare**
- **Accommodate System Degradation**
- **Maximize System Operational Effectiveness**



Communications
- Web enabled
- Radio Frequency
- Infrared/Ultraviolet
- SATCOM
- Databurst Mayday (Black Box Data)



Database Management
- Safety
- Mission Ops
- Rerouting based on Updated Threats
- Configuration Management
- Status Updates
- Schedule Adjustments
- General Maintenance Actions
- Analyze Health of Aircraft Population
- Provide Interactive Electronic Technical Manual (IETM) Knowledge

Maintenance Management
- Web Interfaces
- Maintainer Identification
- Automatic Record of repairs
- Compatibility with legacy systems

Automated Contingency Management

- Employ state-of-the-art computing, communications, and information technologies, in the presence of little or no human intervention to enhance mission effectiveness and survivability
- Automated mission capability updates provided to the aircrew and unit command when system performance degrades
- Various levels of command provided knowledge of the current and predicted capabilities across the population of systems operated
- Maintenance simplified and supply response time reduced
- Piece part reliability provided to OEM's to aid in effecting timely product improvement